What Have We Learned in Seven Conferences on Unburned Carbon on Utility Fly Ash? A Review of Past Conferences

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Summary

The Conference on Unburned Carbon (UBC) on Utility Fly Ash is the only conference in the world devoted solely to this subject. It has become of its own accord a forum for discussing the processing and utilization of high-LOI fly ash, the latest instrumentation for measuring the level of UBC on fly ash, the activation of UBC, the specification and sales potential of high-LOI fly ash, the low level of adsorbed polycyclic organic material, and the levels to which UBC can be reduced by a number of hardware and software combustion modification techniques. It has also kept attendees abreast of the air and waste regulatory issues surrounding high-LOI fly ash.

The Conference was initiated by the National Energy Technology Laboratory (NETL) in 1995 and is now in its eighth year. One hundred and fifty-two presentations later, the Conference has demonstrated that combustion modification technologies have produced often strikingly low NOx emissions. However the NOx emission levels are not low enough to meet the Environmental Protection Agency's (EPA's) pending (May 31, 2004) regulation limit of 0.15 lb NOx per million Btu as the Agency implements Sec. 110 of the 1990 Clean Air Act Amendments. Advanced coal combustion technologies often produce fly ash with unacceptably high levels of UBC and often unsaleable fly ash with unpredictable coloration and carbon content.

The Conference began as an inexpensive, informal meeting for people to talk about the widely observed phenomenon of the lock-step relationship, during even the best controlled combustion, between NOx reduction and an increase in UBC. The Conferences have become somewhat more formal in spite of NETL's efforts, but the Proceedings have been maintained as simple compilations of the presentation Summaries, not formal papers.

During the seven years of the Conference, the regulatory environment for NOx has been a moving target, the development of low-NOx burners (LNBs) has burgeoned, selective catalytic reduction (SCR) and selective non-catalytic reduction (SNCR) have become an increasingly popular major alternative, and hybrid combustion modification and post-combustion technologies are beginning to be implemented on broad commercial scale.

A survey of the presentations made at past Conferences shows an emphasis on processing and utilization of high-LOI fly ash, but they are practically silent on economic issues. Excluding keynote addresses, regulatory and introductory/overview talks, and poster presentations, the seven Conferences can be summarized as follows: Forty-three presentations on Processing and Utilization of High-LOI Fly Ash, 24 on Experiences and Observations, 20 on Predictive Performance Tools, 12 on High-LOI Fly Ash Characterization, 3 on Effects on Specifications and Sales and 1 on Process Economics, for a total of 103 technical presentations.

Of these 103 technical presentations, 12 give laboratory, pilot plant or commercial operating values of UBC on fly ash before and after combustion modifications were made. These technologies were coal reburning, software for combustion optimization, increased coal fineness, inorganic additives to increase slag layer, LNBs, natural gas cofiring, overfire air, and slagging combustors. The values averaged 8.4% UBC (1.1%-25% range) before combustion modifications and 4.1% (0.16%-7.6% range) after. The values are not strictly comparable, because different technologies were used to reduce UBC. However, it can be said that – on average – the installation of LNBs or the acceptance of otherwise inefficient operating conditions approximately doubles UBC levels on fly ash in utility boilers over well operated baseline boilers. The subsequent reduction of UBC (and NOx emissions) by combustion modification technologies reduces unburned carbon approximately to levels of pre-low-NOx operating conditions. Further, the values are by definition the speakers' best results, not typical values. Therefore, the average UBC level in fly ash in United States boilers after combustion modification or boiler fine tuning may well be higher.

The lack of talks on process economics is the most immediately obvious shortcoming in the Conferences and underscores the proprietary nature of economics. Economics of case studies, beneficiation and sales of high-LOI fly ash, and instrumental methods are needed – not only to balance the program – but to provide a more complete description of UBC on utility fly ash.

The Summaries, incorporated in the Proceedings volume for each Conference, are equivalent to a technical handbook on this subject. One can learn almost anything about high-LOI fly ash itself. But none of the talks prescribes how to lower LOI levels by combustion modification sufficiently to meet standard fly ash specifications and simultaneously meet emission limits of 0.15 lb NOx/MBtu. A number of talks make an excellent effort in this direction, and emissions as low as 0.2 lb NOx/MBtu under controlled conditions have been reported. But increased UBC levels still remain practically in lock-step with NOx reduction. This observation means something which is now well known. The Conference presentations have confirmed that control of UBC by combustion modification must be replaced by or coupled with SCR and/or SNCR to meet NOx emission regulatory requirements.

A few years ago, Conference Chair Tom Sarkus concluded this Conference with a list of several areas that we felt needed more R&D. They were:

1. The need for improved characterization of UBC on fly ash – especially in terms of polycyclic organic matter (POM). It was an open question whether UBC contains levels of POM that could trigger Sec.112 of Title I of the Clean Air Act Amendments (Hazardous Air Pollutants). A speaker at the 1997 UBC Conference was able to show that the concentration of POM on four fly ash samples from a large coal-fired power plant was very low: on the order of 30 ppb by weight. The samples contained 5-15% LOI.

2. Potential leaching of POM from landfilled high-LOI fly ash. The answer to the first question indicates the low level of POM in UBC. We have heard no talks or know of any case where a utility fly ash containing higher amounts of UBC has failed a TCLP extraction test – Toxicity Characteristics Leaching Procedure. Further, based upon several regulatory speakers citing EPA waste determinations, it appears that coal combustion byproducts will continue to be regulated as non-hazardous for the foreseeable future.

3. The possibility of using the high-carbon stream from a high-LOI fly ash beneficiation process as a low-grade sorbent for such polluted streams as brackish water. The high-carbon product of high-LOI fly ash beneficiation processes can be on the order of 60% carbon, with a B.E.T. surface area of the order of 10-100 square meters per gram. Researchers at Pennsylvania State University described a procedure for activating UBC, having an initial B.E.T. surface area of 10-60 square meters per gram, to give a product with a surface area of up to 750 square meters per gram. While activated carbons have surface areas generally above 1000 square meters per gram, we are seeing a potential application for UBC as a sorbent.

The UBC Conference has become an annual forum for discussing combustion modification as a means of reducing both NOx emissions and the carbon content of high-LOI fly ash, and attendees have been kept abreast of the regulatory issues. Will the UBC Conference decline after the magic date of May 31, 2004, when enforcement of Sec. 110 of Title I of the Clean Air Act Amendments takes effect [Implementation Plans (the NOx SIP call affecting 19 states and the District of Columbia)]? Much of what draws attendees to this Conference relates to learning what others are doing to meet NOx emission restrictions. The opportunity to hear case studies on what others are doing – or have been doing – to reach and maintain low UBC/NOx emission levels continues. “What Have We Learned?” should take on a very pragmatic tone of “How Have We Fared?” and as important, “What’s Coming Next?” in technology and regulations.